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(12) UK Patent Application (19) GB (11) 2 037 320 A

(21) Application No **7929999**
(22) Date of filing **30 Aug 1979**
(30) Priority data
(31) **78/39117**
79/14682
(32) **3 Oct 1978**
27 Apr 1979
(33) **United Kingdom (GB)**
(43) Application published
9 Jul 1980
(51) **INT CL**^{3}
C22C 19/07
B23K 35/24
C22C 27/06
(52) Domestic classification
C7A 711 A230 A231 A233 A23Y A250 A25Y A280 A289 A28Y A290 A293 A296 A299 A303 A305 A307 A309 A30Y A311 A313 A316 A319 A31X A320 A323 A326 A329 A330 A337 A339 A33Y A340 A341 A343 A345 A347 A349 A34Y A358 A35Y A360 A36Y A375 A377 A379 A37Y A381 A383 A385 A387 A389 A38X A394 A396 A398 A39Y A400 A402 A404 A406 A409 A40Y A414 A416 A418 A41Y A422 A425 A428 A42X A432 A435 A437 A439 A43X A440 A447 A449 A44Y A451 A453 A455 A457 A459 A45X A48Y A495 A497 A499 A501 A503 A505 A507 A509 A50X A514 A517 A519 A51Y A521 A523 A525 A527 A529 A52X A533 A535 A537 A539 A53X A53Y A557 A559 A55Y A562 A565 A568 A56X A571 A574 A577 A579 A57Y A584 A587 A589 A58Y A591 A593 A595 A599 A59X A609 A615 A617 A619 A61X A61Y A621 A623 A625 A627 A629 A62X A671 A673 A675 A677 A679 A67X A681 A683 A685 A686 A687 A689 A68X A68Y A693 A695 A697 A699 A69X A70X
B3R 32G

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C7A

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(54) **Wear resistant alloys**

(57) A wear-resistant alloy, which excluding impurities, has the following composition:
(a) about 50 to 70% of cobalt, nickel and iron; (b) 27 to 35% of chromium;
(c) 5 to 15% of molybdenum and/or tungsten; (d) 0.3 to 2.25% of carbon and/or boron; (e) 0 to 3% of silicon and/or manganese; (f) 0 to 5% of one or more of titanium, hafnium, zirconium, vanadium, niobium, and tantalum; (g) 0 to 5% of copper, and (h) 0 to 2% of one or more rare earths. The cobalt is the range 25 to 40%, and the nickel in the range 4 to 12%. There is from 0 to 7.5% of constituents (f), (g) and (h). The iron is present in a quantity not exceeding 25%. If there is 2% or more of carbon and/or boron, there is more than 30% chromium. (All percentages by weight). Up to 2% aluminium may also be present.

A welding or surfacing consumable which (ignoring the effect of dilution by substrate) is capable of depositing such an alloy may also be made.

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SPECIFICATION

Alloys

This invention relates to alloys and surfacing and welding consumables. In particular, it relates to alloys which contain cobalt and which are resistant to wear and to surfacing and welding consumables which contain cobalt and which are resistant to wear.

Wear-resistant alloys based on the Co-Cr-W-C quaternary system are well known. They comprise a dispersion of hard carbide particles within a strong corrosion-resistant solid solution, rich in cobalt. The strength of the solid solution is such that only moderate volumes of carbide need be employed to achieve a given bulk hardness at both room and elevated temperature. Material toughness is thus appreciable.

The balance between solid solution strength and carbide level and thus between hardness and toughness of these alloys is such that they are able to withstand wear under both moderate and extreme conditions of temperature and stress (static and cyclic).

A range of such alloys is available, varying in room temperature hardness from approximately 300 VPN to 700 VPN, to suit different applications.

Typically, alloys of hardness of approximately 400 VPN contain 1 wt % carbon, 26 wt % chromium and 5 wt % tungsten, whilst those of hardness approximately 600 VPN contain 2.5 wt % carbon, 33 wt % chromium and 13 wt % tungsten. Not only do the chromium and tungsten contribute to the strength of the solid solution, they also act as carbide formers. The high strength of the cobalt-rich solid solution is associated with a high stacking fault density therein.

In recent years, cobalt has become an expensive commodity. The commercial need to reduce the level of cobalt in such alloys, whilst retaining their excellent wear characteristics, is therefore great.

Merely to substitute iron and nickel for some of the cobalt is an unsatisfactory expedient. A reduction in cobalt level in these alloys and a corresponding increase in iron or nickel bring about a reduction in solid solution strength and bulk hardness.

To compensate, increased levels of carbon (and hence carbide) can be employed. Many reduced cobalt alloys contain increased levels of carbide. The toughness of such materials and their ability to withstand severe wear situations are, however, limited.

It is an aim of the present invention to provide a range of reduced cobalt alloys which are acceptable alternatives to the Co-Cr-W-C alloys. Compensation is achieved through enhanced strengthening of the solid solution, thus retaining to a large extent the balance between solid solution strength and carbide level of the Co-Cr-W-C alloys.

The invention provides an alloy having (excluding impurities) essentially the following composition, or a surfacing or welding consumable whose formulation is such that on being melted it is capable of producing an alloy which (ignoring the effect of any dilution thereof by substrate material) has essentially the following composition (excluding impurities):

		% by weight of the composition
(a)	cobalt, nickel and (if present) iron	about 50 to 70
(b)	chromium	27 to 35
(c)	molybdenum and/or tungsten	5 to 15
(d)	carbon and/or boron	up to 2.25
(e)	silicon and/or manganese	0 to 3
(f)	one or more of titanium, hafnium, zirconium, vanadium, niobium and tantalum	0 to 5
(g)	copper	0 to 5
(h)	one or more rare earths	0 to 2

wherein:

(i) cobalt is present in the range 25 to 40% by weight;

(ii) nickel is present in the range 4 to 12% by weight;

(iii) if any is present, the total weight of constituents (f) to (h) is 7.5% or less;

(iv) iron does not exceed 25% by weight;

(v) if there is 2.0% or more by weight of carbon and/or boron present, there is more than 30% by weight of chromium.

We believe that alloys having properties akin to conventional Co-Cr-W-C alloys can be produced in accordance with this general formulation. The selection of a particular alloy in accordance with the general formulation may be made so as to meet specific requirements (such as a specified hardness).

The enhanced strengthening of the solid solution is achieved by using, at relatively high atomic levels, chromium and molybdenum, the latter being in some instances partially or entirely 'replaced' by tungsten.

Typically, the alloys according to the invention may contain in the order of 30% (by weight) less cobalt than the conventional Co-Cr-W-C alloys with comparable properties.

We typically prefer to employ more than 10% by weight of iron and typically from 15 to 20% by weight of iron in the composition. The nickel helps to stabilise the face-centred cubic structure of the solid solution. If the alloy is formed into an arc welding consumable, it should be borne in mind that metal from the work being welded may intermix with the weld metal and thus dilute it. Thus, if the arc welding consumable is to be used for the arc welding of ferrous metal it will typically be desirable for more than 5% by weight of nickel to be present in the consumable.

If desired, the composition according to the invention may contain no tungsten. Preferably, it contains at least 2% and more preferably at least 5% by weight of molybdenum. Not only does this element provide solid solution strengthening; like chromium, it enhances the resistance to corrosion.

Preferably, the composition according to the invention contains no boron. If boron is present it preferably does not constitute more than 1% to the total weight of the composition, with carbon also being present. If the combined weight of carbon and boron is greater than 1.5% by weight then preferably at least 1.25% of carbon is present. Generally, there is at least 0.3% by weight of carbon present in an alloy according to the invention. Typically, to be suitable for exposure to a wide range of conditions conducive to wear, the composition contains between 0.9 and 1.5% by weight of carbon with there being no boron present. At higher carbon levels the alloys tend to have increased hardness but reduced toughness, and *vice versa* at lower carbon levels. It is a characteristic feature of alloys according to the invention that they have relatively good wear resistance while containing a relatively low level of cobalt and no exceptionally high level of carbon and boron.

Typically, from 0.5 to 2.0% (preferably from 0.5 to 1.5%) by weight of silicon and/or manganese are present. These constituents increase the fluidity of the alloys when molten.

If desired, alloys according to the invention may include up to 5% by weight of one or more elements which are highly active carbide formers. These elements modify the type and morphology of the carbides and release more molybdenum (and/or tungsten) to the solid solution. The highly active carbide former(s) may be selected from tantalum, niobium, hafnium, vanadium titanium and zirconium. These may be up to 5% of such carbide former present. Preferably if one or more of such carbide formers are employed, titanium and/or niobium are selected. It is not essential, however, to include such 'highly active carbide formers'.

If desired, alloys according to the invention may contain up to 5% of copper which enhances their resistance to certain corrosive media. Copper is, however, neither an essential nor a preferred constituent of alloys according to the invention.

If desired, alloys according to the invention may contain up to 2% by weight of one or more rare earths. We believe that the inclusion of such rare earth(s) may be desirable if any alloy according to the invention is required to have particularly good resistance to oxidation at high temperatures (particularly above 1000°C). The preferred rare earth for this purpose is yttrium. However, other rare earths such as lanthanum thorium or cerium may be used instead. The inclusion of a rare earth is not an essential feature of the invention, but is optional.

A preferred composition is:

	% by weight of the composition
cobalt	25 to 40
chromium	27 to 35
molybdenum and/or tungsten	5 to 15
nickel	5 to 10
carbon and/or boron	up to 2.25
silicon and/or manganese	0 to 3
one or more of hafnium, zirconium, niobium, titanium, tantalum and vanadium	0 to 5
copper	0 to 2
one or more rare earths	0 to 2
iron	balance

wherein hafnium, zirconium, niobium, titanium, tantalum, vanadium, copper and the rare earths does not exceed 7.5% by weight (and preferably does not exceed 5% by weight), and there is not more than 25% by weight of iron present.

If tungsten is present and the aforesaid preferential carbide formers absent the sum of the percentage weight of molybdenum plus half the percentage weight of tungsten is preferably in the range 5 to 10%.

Preferably for a general purpose wear resistant alloy the cobalt is present in the range 28 to 38% by weight (and more preferably 28 to 35% by weight).

Particularly preferred compositions (excluding impurities) are as follows:

	% by weight of the composition
cobalt	28 to 38
chromium	27 to 35
molybdenum and/or tungsten	5 to 10
nickel	5 to 10
carbon	0.5 to 2
silicon and/or manganese	0 to 3
iron	balance (but not more than 25)

and

	% by weight of the composition
cobalt	27 to 35
chromium	27 to 35
molybdenum and/or tungsten	5 to 10
nickel	5 to 10
carbon	0.5 to 2
silicon and/or manganese	0 to 3
iron	(but not more than 25)

Preferably tungsten and manganese are absent. Typically, there is from 8 to 24% by weight of iron. For a versatile wear-resistant composition, there is typically from 15 to 20% by weight or iron. There is typically from 0.9 to 1.5% by weight of carbon. Typically, there is from 0.5 to 2% (preferably 0.5 to 1.5%) by weight of silicon.

There is, as aforementioned, a range of conventional cobalt-tungsten-chromium-carbon alloys that is commercially available. In this range of alloys the proportions of chromium and tungsten present increase with increasing carbon. Analogously, in the alloys according to the invention, the more carbon that is employed, the greater is the proportion of chromium that should preferably be present, and the greater is the proportion of molybdenum and/or tungsten that should be employed. Moreover, the chromium can typically be at least 31% if the carbon is at least 1.2% by weight.

Typically, with increasing carbon, the combined proportions of iron, nickel and cobalt in the alloys are reduced. Typically, there is a greater proportion of iron than nickel in an alloy according to the invention. At a carbon and/or boron level of 2.25% by weight, the combined level of cobalt, nickel and iron may be 50% or just below (down, say, to 48% by weight).

The alloys according to the present invention may be prepared by mixing their respective ingredients and melting the resultant mixture, typically in a furnace, and typically at a temperature in the order of 1550°C. If desired, the melting may take place in a protective atmosphere of inert gas such as argon or nitrogen or under vacuum. The molten alloy may be formed into a powder by being atomised or by other means, may be made as a casting by, for example, poured into an appropriately shaped mould or may be formed into a cored wire or rod. The powder, wire or rod may be used as hard facing or welding consumables which may, if desired, be coated with a suitable flux. It may also, we believe, be possible to make forgings from alloys according to the invention, if their carbon content is typically less than 1% by weight.

If desired, engineering or other components may be made as a casting or forging from an alloy according to the invention. Alternatively, such components may be formed by compacting and/or sintering a powder which is an alloy according to the invention.

The alloys according to the invention may be employed in substantially all applications for which conventional cobalt-based wear resistant alloys are currently used.

A surfacing consumable according to the invention may be used to deposit a wear resistant coating on a substrate. A welding consumable according to the invention may be used to deposit wear resistant weld metal.

An alloy according to the invention may be shaped so as to provide the surfacing or welding consumable. It may also include materials which in use of the consumable are not intended to become an integral part of the metallic deposit. Such materials include for example flux and arc stabilisers. For example a rod or alloy according to the invention may be coated with flux and/or arc stabilisers to form a welding or surfacing consumable according to the invention.

It is possible to produce what is in effect a chemical equivalent to a welding or surfacing consumable according to the invention. In such an equivalent consumable the alloy is in effect formed *in situ* as a metallic deposit from the consumable. This metallic deposit may be diluted almost instantaneously by the base or substrate material diffusing into or intermixing with the deposit, or *vice versa*. For example, some but not all

constitutes of the metallic deposit may be present in one discrete part of the consumable and others in another part. Thus, for example, say cobalt and iron are present in an alloy form as a hollow tube, and, say, nickel, molybdenum, chromium, silicon and carbon as a powder within the tube. The tube may also typically contain a flux and arc stabilising materials. A typical example is that the tube is of an alloy containing 60% by weight of cobalt and 40% by weight or iron.

Typically the kind of consumable in which some but not all constituents are present in one discrete part of the consumable and others in another part may take the form of a cored wire. Typically, in such a consumable there will be near to 100% recovery of all the constituents of the consumable in the deposit excluding arc stabilisers, flux and the like, and also with the exception that not all the silicon and/or manganese will in general be recovered, particularly if the consumable contains a flux, in which instance, in use, a part of the silicon and/or manganese tends to enter the slag which forms on the surface of the metallic deposit. Typically, the consumables may therefore contain 1 to 2% by weight more silicon and/or manganese than it is intended to recover in the deposit.

The term 'impurities' as used herein encompass both adventitious impurities and any element or substance deliberately added which does not influence significantly the properties of an alloy according to the invention. For example, small amounts of aluminium (say 1 or 2% by weight) may be included without significantly altering the properties of the alloy.

Desirably, relatively pure constituents are employed in making an alloy acording to the invention as they are when making conventional cobalt-based wear-resistant alloys.

Examples of alloys according to the invention are set out in Tables 1, 2, 3 and 4. Some of their properties are set out in Table 5. Table 6 sets out the composition of conventional cobalt-based alloys. Table 7 illustrates the properties of the alloys set out in Table 6.

TABLE 1

Alloy	% by weight								
Ref. No.	Co	Cr	Ni	C	Fe	Si	Mo	Mn	B
1	33	29	8	0.3	22.7	1	6	-	-
2	33	31	8	0.75	18.25	1	8	-	-
3	33	31	8	1.2	17.8	1	8	-	-
4	33	31	8	1.3	17.7	1	8	-	-
5	32	32	8	1.5	16.5	1	9	-	-
6	31	33	8	1.75	15.25	1	10	-	-
7	31	34.5	8	1.9	13.1	1	10.5	-	-
8	30.25	35	8	2.25	11.75	0.75	12	-	-
9	33	31	8	0.75	17.75	1	8	-	0.5
10	33	31	8	1.3	17.7	-	8	1	-
11	33	31	4	1.3	21.7	1	8	-	-
12	33	31	6	1.3	19.7	1	8	-	-
13	33	31	10	1.3	15.7	1	8	-	-
14	33	31	12	1.3	13.7	1	8	-	-
15	25	31	10	1.3	23.7	1	8	-	-
16	28	31	8	1.3	22.7	1	8	-	-
17	35	31	8	1.3	15.7	1	8	-	-
18	40	31	6	1.3	12.7	1	8	-	-

TABLE 2

Alloy Ref. No.	% by weight Co	Cr	Ni	C	Fe	Si	Mo	Nb	Cu	W	Y	Ti	Zr	V	Ta
19	31	29	8	1.3	22.3	1	5.5	2	-	-	-	-	-	-	-
20	31	31	8	1	17	1	8	3	-	-	-	-	-	-	-
21	31	31	8	0.75	15.25	1	8	5	-	-	-	-	-	-	-
22	32	31	8	1.3	17.7	1	8	-	-	-	1	-	-	-	-
23	31	31	8	1.3	16.2	1	8	-	2.5	-	-	-	-	-	-
24	33	31	8	1.2	17.8	1	5	-	-	3	-	-	-	-	-
25	31	31	8	1.3	17.7	1	8	-	-	-	-	2	-	-	-
26	31	31	8	1	17	1	8	-	-	-	-	-	3	-	-
27	31	31	8	1.3	17.7	1	8	-	-	-	-	-	-	2	-
28	31	31	8	1.3	17.7	1	8	-	-	-	-	-	-	-	2
29	31	27.7	8	0.45	24.75	1	5.6	1.5	-	-	-	-	-	-	-
30	33	31	8	1.3	17.7	1	3	-	-	5	-	-	-	-	-

TABLE 3

Alloy Ref. No.	% by weight (as analysed) Co	Cr	Ni	C	Fe	Si	Mo	Mn	B
31	31.7	30.4	8.4	1.3	17.5	1.1	7.9	-	-
32	balance	30.9	8.0	1.6	18.0	0.4	8.5	-	-
33	balance	32.5	8.0	1.7	15.3	0.4	10.4	-	-
34	balance	33.6	8.2	2.0	14.8	0.5	8.4	-	-
35	balance	35.2	8.6	2.2	12.0	0.8*	11.0	-	-
36	balance	30.0	7.7	0.9	19.5	0.6	8.5	-	0.5*
37	33.3	29.8	8.0	1.4	17.0	0.6	8.2	0.8	-
38	balance	28.8	4.1	1.3	24.3	0.4	7.9	-	-
39	balance	29.1	5.7	1.4	22.9	0.5	7.4	-	-
40	balance	29.4	9.6	1.3	18.6	0.5	7.6	-	-
41	balance	28.9	11.4	1.3	16.6	0.5	7.3	-	-
42	balance	29.6	9.7	1.4	25.4	0.6	7.3	-	-
43	balance	29.3	7.8	1.3	24.4	0.6	7.2	-	-
44	balance	29.5	8.1	1.4	20.4	0.7	6.5	-	-
45	balance	29.7	6.0	1.4	16.6	0.6	5.9	-	-

Notes

- balance indicates percent by weight of cobalt plus impurities
- * indicates nominal composition

TABLE 4

Alloy Ref. No.	% by weight (as analysed) Co	Cr	Ni	C	Fe	Si	Mo	Nb	Cu	W	Y	Ti	Zr	V	Ta	Mn
46	balance	30.8	8.8	0.8	15.2	1*	7.1	5*	-	-	-	-	-	-	-	-
47	balance	29.3	7.9	1.4	19.2	0.5	8.3	-	-	-	1*	-	-	-	-	-
48	balance	29.2	7.9	1.4	19.2	0.6	8.0	-	2.4	-	-	-	-	-	-	-
49	33.3	30.1	8.0	1.3	17.0	1.0	5.1	-	-	4.1	-	-	-	-	-	-
50	balance	29.3	7.9	1.4	22.8	0.8	7.6	-	-	-	-	2*	-	-	-	-
51	balance	30.0	7.9	1.1	16.1	1.0	8.5	-	-	-	-	-	3*	-	-	-
52	balance	30.7	7.8	1.4	18.6	0.5	7.9	-	-	-	-	-	-	2.0	-	-
53	balance	29.2	8.3	1.5	19.2	0.6	7.9	-	-	-	-	-	-	-	2*	-
54	balance	28.2	7.7	0.5	21.6	1*	-	4.2	-	6.1	-	-	-	-	-	1*
55	balance	29.9	7.8	1.3	18.5	0.4	-	-	-	8.2	-	-	-	-	-	-
56	balance	29.9	7.7	1.4	18.8	1*	-	-	-	11.5	-	-	-	-	-	-
57	balance	30.6	9.1	1.2	19.0	0.4	6.3	-	-	1.4	-	-	-	-	-	-
58	balance	28.2	7.8	0.3	24.1	0.5	5.7	-	-	2.25*	-	-	-	-	-	-

Notes
- balance indicates percent by weight of cobalt plus impurities
- * indicates nominal composition

TABLE 5

Alloy Ref.	Hardness (Vickers Pyramid No.)	Ultimate Tensile Strength (at room temperature) Ton F/in²	H Bar	% Elongation (%) (at room temperature)	Corrosion in aqua regia at room temperature (% weight loss in 100 hours)	Oxidation at 900°C (% weight gain in 25 hours)
31	434	45	69.5	1.0	5.8	0.016
32	425	39	60	0.5	8.0	0.020
33	512	36	56	0.5	7.7	0.018
34	494	38	59	0.5	7.1	0.023
35	585	23	35.5	< 0.5	9.3	0.016
36	373	44	68	1.0	5.8	0.010
37	442	39	60	1.0	6.9	0.019
38	397	40	62	< 0.5	6.7	0.025
39	395	43	66	0.5	7.6	0.028
40	374	42	65	0.5	8.0	0.016
41	363	41	63	1.0	7.7	0.014
42	362	43	66	1.0	8.3	0.019
43	369	44	68	0.5	7.8	0.031
44	373	44	68	1.0	7.6	0.023
45	391	44	68	1.0	7.5	0.024
46	468	35	54	0.5	3.2	0.022
47	407	22	34	0.5	7.5	0.010
48	377	43	66	1.0	7.6	0.020
49	436	43	66	0.5	2.4	0.013
50	395	*	*	*	6.4	0.025
51	391	*	*	*	4.4	0.034
52	400	46	71	1.0	6.9	0.112
53	416	45	69.5	0.5	5.9	0.022
54	363	45	69.5	3.0	3.8	0.016
55	375	49	76	1.5	5.4	0.015
56	392	42	65	0.5	4.7	0.016
57	356	34	52.5	0.5	6.6	0.021
58	330	47	73	2.0	3.6	0.020

Notes
* indicates that no measurement was taken

For the oxidation and corrosion tests, standard samples of 30 cm^2 were used.

TABLE 6

Alloy Ref.	Co	Cr	Ni	C	Fe	Si	W
A	63	26	1	1	3	1	5
B	56	29	1	1.8	2.2	1	9
C	47	33	1	2.5	2.2	1	13

TABLE 7

Alloy Ref.	Hardness (Vickers Pyramid No.)	Ultimate Tensile Strength (at room temperature)		% Elongation (%) (at room temperature) loss in	Corrosion in aqua regia at room temperature (% weight 100 hours)	Oxidation at 900°C (% weight gain in 25 hours)
		Ton F/in^2	H Bar			
A	420	54	80	1.0	6.5	0.019
B	502	43	66	0.5	4.9	0.015
C	567	26	40	0.5	3.8	0.012

All the alloys that were subjected to the tests set out in Table 5 were formed as identical castings.

The alloy A (see Table 3) is sold widely under the trade mark 'Stellite 6'-. ('Stellite' is a Registered Trade Mark). We believe that alloy No. 31 according to the invention is an acceptable alternative for most, if not all, commercial applications of 'Stellite 6'.

We have found that at 700°C, the hardness of an alloy such as No. 31 is about 80% of that of alloy A, and at 800°C the UTS of alloy No. 31 is greater than that of alloy A. Moreover, the oxidation resistance of alloy No. 31 in the temperature range 600 to 900°C is approximately equal to that of alloy A. Generally, the resistance of alloy No. 31 to commonly encountered acid solutions is greater than that of alloy A.

The alloys according to the invention are less affected by iron dilution during arc welding than are conventional cobalt-based hard metal alloys (such as 'Stellite 6'). Selection of an appropriate alloy according to the invention will depend upon the surfacing technique and conditions of deposition.

CLAIMS

1. An alloy, or a surfacing or welding consumable whose formulation is such that on being melted it is capable of producing an alloy which (ignoring the effect of any dilution thereof by substrate material) has essentially the following composition (excluding impurities):

		% by weight of the composition
(a)	cobalt, nickel and (if present) iron	about 50 to 70
(b)	chromium	27 to 35
(c)	molybdenum and/or tungsten	5 to 15
(d)	carbon and/or boron	0.3 to 2.25
(e)	silicon and/or manganese	0 to 3
(f)	one or more of titanium, hafnium, zirconium, vanadium, niobium and tantalum	0 to 5
(g)	copper	0 to 5
(h)	one or more rare earths	0 to 2

wherein
(i) cobalt is present in the range 25 to 40% by weight;
(ii) nickel is present in the range 4 to 12% by weight;
(iii) if any is present, the total weight of constituents (f) to (h) is 7.5% or less;
(iv) iron does not exceed 25% by weight;

(v) if there is 2.0% or more by weight of carbon and/or boron, there is more than 30% by weight of chromium.

2. An alloy or consumable as claimed in claim 1, wherein the said composition includes at least 2% by weight of molybdenum.

3. An alloy or consumable as claimed in claim 1 or 2, in which tungsten is absent from the said composition.

4. An alloy or consumable as claimed in any one of the preceding claims in which boron is absent from the said composition.

5. An alloy or consumable as claimed in any one of the preceding claims, wherein the said composition includes at least 0.5% by weight of carbon.

6. An alloy or consumable as claimed in any one of the preceding claims, wherein the said composition includes 0.9 to 1.5% by weight of carbon.

7. An alloy or consumable as claimed in any one of the preceding claims, in which rare earth elements are absent from the said composition.

8. An alloy or consumable as claimed in any one of claims 1 to 6, in which the rare earth is yttrium.

9. An alloy or consumable as claimed in any one of the preceding claims, in which copper is absent from the said composition.

10. An alloy or consumable as claimed in any one of the preceding claims in which vanadium, tantalum, niobium, hafnium, zirconium and titanium are all absent from the said composition.

11. An alloy or consumable as claimed in any one of the claims 1 to 9, in which one or both of titanium and niobium are present in the said composition.

12. An alloy or consumable as claimed in any of the preceding claims, in which the said composition contains from 5 to 10% by weight of nickel.

13. An alloy or consumable as claimed in any one of the preceding claims, in which the total amount of constituents (f) to (h) is less than 5%.

14. An alloy or consumable as claimed in claim 12 or 13, in which the constituents (f) to (h) are absent from the said composition.

15. An alloy or consumable as in any one of the preceding claims, wherein the said composition includes from 27 to 38% by weight of cobalt.

16. An alloy or consumable as claimed in claim 15, wherein the said composition includes from 27 to 35% by weight of cobalt.

17. An alloy or consumable as claimed in any one of the preceding claims, in which the combined weight of carbon and boron is greater than 1.5% by weight, and there is at least 1.25% by weight of carbon present in the said composition.

18. An alloy or consumable as claimed in any one of the preceding claims, in which there is more iron than nickel in the composition.

19. An alloy or consumable as claimed in claim 1, in which the aforesaid composition is (excluding impurities) as follows:

	% by weight of composition
cobalt	28 to 38
chromium	27 to 35
molybdenum and/or tungsten	5 to 10
nickel	5 to 10
carbon	0.5 to 2
silicon and/or manganese	0 to 3
iron	balance

there being not more than 25% by weight of iron.

20. An alloy or consumable as claimed in claim 1, in which the aforesaid composition is (excluding impurities) as follows:

	% by weight of composition
cobalt	27 to 35
chromium	27 to 35
molybdenum and/or tungsten	5 to 10
nickel	5 to 10
carbon	0.5 to 2
silicon and/or manganese	0 to 3
iron	balance (but not more than 25% by weight)

21. An alloy or consumable as claimed in claim 19 or claim 20, in which the composition includes 8 to 24% by weight of iron.

22. An alloy or consumable as claimed in claim 21, in which the composition includes 15 to 20% by weight of iron.

23. An alloy or consumable as claimed in any one of claims 19 to 22, in which the composition includes from 0.9 to 1.5% by weight of carbon.

24. An alloy or consumable as claimed in any one of claims 19 to 23, in which the composition includes from 0.5 to 1.5% by weight of one or both or silicon and/or manganese.

25. An alloy having any one of the compositions set out in Tables 1 to 4.

26. A component made from an alloy as claimed in any one of the preceding claims.

27. A consumable as claimed in any one of claims 1 to 24, which has the form of a cored wire.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon Surrey, 1980.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.